This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Chem
7238
64

Chem 7238.64

Harvard College Library

FROM

Charles Eliot Norton

SCIENCE CENTER LIBRARY

THE

MANAGEMENT OF STEEL,

INCLUDING

FORGING, HARDENING, TEMPERING, ANNEALING, SHRINKING, AND EXPANSION;

ALSO THE

CASE-HARDENING OF IRON.

By GEORGE EDE,

EMPLOYED AT THE ROYAL GUN FACTORIES DEPARTMENT, WOOLWICH ARSENAL.

FIRST AMERICAN—FROM SECOND LONDON EDITION.

NEW YORK:
D. APPLETON AND COMPANY,
443 & 445 BROADWAY.
1864.

Chem 723864

1864, June 6.
Gift of
Chas. Eliot Norton,
[illegible]
(Class of 1846)

PREFACE.

FORGING, hardening, and tempering of Steel is an art very much admired; the agreeable exercise it affords to the mind, its beauty and utility, often entice the young mechanic to try his skill, or rather to gain a little knowledge of the tools he uses; and it will be my endeavour to point out the way in as simple a manner as possible, which will enable the most inexperienced to gain a thorough knowledge in the hardening and tempering of the tools they use, likewise the qualifications a tool should have to be considered a good-shaped tool; and it will not, I presume, prove uninteresting to the general reader. It is an art of long standing; but by whom or when it was first adopted I am not prepared to decide. In this place it claims notice on account of its contributing so essentially to the perfection of all other arts; and having myself had long ex-

perience in the art, and wrought among thousands of different mechanics, I have had an opportunity of seeing that such a work as the present is wanting among them; and being prevailed upon to write it, I have taken the advantage of a few leisure hours, not merely to write hearsay, but practical experience.

G. E.

20, *Somerset Terrace,*
Raglan Road,
Plumstead.

THE MANAGEMENT OF STEEL.

ON THE FORGING OF STEEL.

STEEL being one of the most valuable metals and requiring great care in the forging, hardening, tempering, annealing, and management of it in general, I think, after having had nearly twenty years' good practice, experience, and study combined, I am now able to give a little information to those who have not had so much to do with it as I have. All that I here state is from my own practical experience; and by following the plans I shall here give, the artist will meet with every success. There are many people who, for the want of a little useful knowledge on steel, refrain from making many a good tool, because they say it is sure to crack in hardening; but if the steel is good, and has not been spoilt in forging the article, then, by following my plans they never need be afraid that it will be a "waster." There are tons of the very best steel condemned as bad steel—when at the same time it

is the forging of it that has made it bad, through men not having a proper knowledge in the management of it; and those masters who study their own interest will only employ those men for the forging of steel on whom they can most depend. For I have seen plenty of the very best steel destroyed, and have even heard men remark to each other, "Make it well hot—it will work the easier;" and I felt what a sad thing it was to see men that knew better; yet they would destroy their employer's property. Therefore I say, as justice to the manufacturer and supplier of steel, it behoves masters to put those men only at the forging of steel on whom they can most depend.

In forging of cast steel the fire must be regulated by the size of the work; and in heating the steel, when the flames begin to break out, beat the coals round the outside of the fire close together with the slice to prevent the heat from escaping. To save fuel, damp the coal, and throw water on the fire if it extend beyond its proper limits. To ascertain the heat of the steel, draw it out of the fire, and that often, for it requires to be well watched to heat the steel properly; and if not hot enough, thrust it quickly in again. Soft coke is even better than coal for the fire. The heat the steel receives is judged of by the eye; and care should be taken not to use a higher degree of heat than is absolutely

necessary to effect the desired purpose, and to use as few heats as possible; too frequent and overheating steel abstracts the carbon, gradually reducing it to the state of forged iron again. It is an idea of many men, that so long as the steel does not fly to pieces when they strike it with the hammer, it is not too hot; but it is an erroneous idea, and easily proved when it comes to be hardened, and when it comes to be used; still it is an idea that many men will maintain, but only for the want of knowing better, and I hope that this will have the effect of altering their opinion. I can safely say that no man will ever injure the steel by being too careful how he takes his heats. Cast steel may be welded by boiling sixteen parts of borax and one of sal ammoniac together over a slow fire for an hour, and when cold grinding it into a powder. The steel must then be made as hot as it will conveniently bear, and the borax used as sand.

ON THE HARDENING OF STEEL.

My object now is to show to the reader some of the chief causes of steel breaking in hardening, and likewise to give a few remedies to prevent these causes; and I am sure, from my own experience, that whoever tries them will find them correct. In the first place, I wish to apprise the reader that all

bright steel requires a coating of some description before putting it in the water, more especially when the article runs large; or the sudden action of the water on the outside of the steel in most instances is sure to crack it. As a proof of this, take a piece of steel cut from a bar with the skin on, harden it as often as you please, and you will find it is a very uncommon thing for that either to crack or break, if it is not made too hot; but take the same piece of steel, or another piece from the same bar, file or turn it bright, and it is quite likely to break the first time it is hardened. As a proof that the skin on the steel prevents the water from acting so suddenly on the outside of the steel, in cooling it so much sooner than the middle, common turning tools will always stand better, and keep a finer edge, if the tools are hardened from off the hammer with the skin on, to what they will if they are either filed or ground before hardening; that is, if the heat of the steel is regulated so as not to require tempering after being made hard. For the most useful hardness is produced by that degree of heat which is just sufficient to effect the purpose, the hardness of steel depending upon the intimate combination of its carbon; therefore the heat which effects this is the best. But there are a number of tools used in the turnery that cannot be ground after hardening, therefore these must be fitted up

with the file, and the necessary precautions used in hardening them; for not being able to grind them after they are hardened, owing to their peculiar shapes, it is a matter of importance that these should stand well, for were the edge to chip through being a little too hard, or the edge to rub off through being a little too soft, the tool must be softened and fitted up again, and in many instances the tool would be wholly useless, for the proper size of it would be gone. Therefore, if extra care is to be taken with some tools, it is the like of tools that cannot be repaired. But all tools that can be ground after being hardened are the better for being hardened with the skin on the steel; and if the tool-smith understands his business, he knows the proper shape of the tools as well as the mechanic who is using them, and he will give very little grinding on the tools, and as for water cracks there will be none. In the hardening of steel, it demands a nicety of management which some artists are not often very anxious to display, and there are some who would not give themselves the trouble to do what they really know is requisite before they put the article in the fire, therefore they put it in and chance their luck. But Luck has never been my motto—Success is what I have always aimed at; it has always been my plan if I never gained credit, to take care I never lost any; and I hope this will

act as a word of advice to many young men just starting in the world. Before putting any article in the fire it is necessary to examine its shape, as every article has a particular way in which it should go into the water; therefore, it is requisite to know, before it is put into the fire, which way it is to be put into the water when it is drawn from the fire; likewise the water has to be studied into which the article is put, and likewise the heat on the article before it is put in the water, and the position of it in putting it in the water. Water that is intended for hardening with should never be dead cold; and the heat of the article, if the steel is good, should never exceed that of a low red heat; for if the water is dead cold, and the steel a little too hot, there is as much risk of its breaking as there is in pouring boiling water into a glass bottle; for dead cold water acting so suddenly on the outside of the steel, the expansion of the middle is more than the outside can bear, and causes the steel to break; therefore, to avoid such risk, get a quantity of lighted charcoal, or a bar of ignited iron, and put it in the water, just sufficient to take the chill off. In dipping any article in the water, if there is a stout part and a thin part, always let the stoutest part go into the water first, and as near the centre of the water as possible, so that there may be an equal pressure of water surrounding it. Putting

the stoutest part in the water foremost causes the article to cool more equally, whereas if the thin part be put in the water foremost it is cold first, and the stout part having to contract after the thin part is cold, the thin part cannot give, consequently it has to break. But this cannot always be done, as there are no means of getting the stoutest part of some articles in the water foremost; for instance, such an article as a feather edge milling cutter, and many other things which have their stoutest part in the centre—these must be put in perpendicularly by putting a piece of strong wire through the hole in the centre, and putting it gently into the water; and instead of moving it backwards and forwards in the water, lift it up and down, so that fresh water may pass through the centre every time it is lifted up and down, and the deeper the tank the better. But in lifting it up it must not be allowed to come above the water, or it will be sure to crack; the outside edges of such articles being much thinner than the middle they are cold sooner, so that the middle is wanted cold as quickly as possible after the outside edges; and were it drawn backwards and forwards in the water, the water being warm in the hole in the centre, it would be longer in cooling. The outer edge being dead cold, and the middle of the cutter contracting, the outside is too cold to give, so it ends in the article breaking; but by

a little attention to the above they are accomplished without breaking them. The wire that is used to bear the cutter while dipping it in the water must have three forks at the end for the cutter to lie upon, so that there is no obstruction to the water passing freely through the hole. With the inexperienced it is just heat it, and put it in the water, without regard to anything which causes such losses to the employer, and then it is condemned as bad steel! but it is not all bad steel that breaks, for the very best steel will break if it is not properly managed.

I speak from experience that the shape of different articles has to be studied; for instance, take such an article as an eccentric collar, which shall be 1¼ inch thick on one side, and ¼ of an inch on the other, having a 2-inch hole in it for the shaft; in hardening this it is most certain to break in the weak side, for one side being so thin, it is cold almost instantly, and the stout side contracting after the other is cold, it pulls it asunder. By taking a little trouble all this risk is avoided. Before such an article as the above be put in the fire, fit a piece of iron round the thin part, so that it is made up to the thickness of the stout part, or a little thicker, and bind it on with a piece of binding wire, and coat it with potash, and I will guarantee that it hardens without breaking, because one part then is

cold as soon as the other. There are various things that steel can be coated with, such as soft soap, black lead, or plumbers' size; but in hardening in a common fire, or a furnace, the prussiate of potash is the best. In hardening in lead, soft soap, black lead, or plumbers' size answers exceedingly well. In coating of steel, you first get the article just red, draw it from the fire, having the potash already powdered up fine, and in a box with small holes in the lid, similar to a grater; shake the box till there is a coat all over the articles, put it in the fire again till it gets to the desired heat, and it is then ready to put into the water, except in very large articles, where there is a great body of steel. It is requisite then to draw it from the fire a second time, and give it another sprinkle of potash, so as to give it a thicker coat. By binding a little binding wire about it, it assists to make the potash cling more firmly to it. There are many things that require to be hardened, where the substance of the steel is so great that it is necessary to bore holes about it in different places to make it cool more equally. In very large cutters, some are apt to have the hole where the spindle passes through too small, so that large and small cutters may fit the same spindle; but the larger the cutter the larger the hole should be; or otherwise bore a few holes round the middle hole, so that the substance of the

steel is reduced, or it may be reduced by turning it thinner, so as to form a boss each side, thus greatly reducing the risk of its breaking in hardening. But if it happen that any article that has to be hardened has any holes about it near to the very edge, it is then requisite to stop these holes up with a piece of loom, and it will prevent the hole breaking out. Any size cutters, bushes, gauges, rings, or collars, or articles of any description may be hardened without breaking by following the rules I here lay down. Sometimes a steel ring or a cutter is required to have one thin edge; these must be put in the water with the stoutest part downwards, and if the edge is very thin, it must not be put in the water too suddenly. In very large round steel it is sometimes necessary to bore a hole through the centre to allow the water to pass through, and even then it will break asunder if it be drawn backwards and forwards in the tank; this should always be lifted up and down in the water to allow fresh water to pass through the hole, unless when it is under the water; if it be turned on to its side, it can then be drawn backwards and forwards with the same result. It sometimes happens that there is a fracture in the steel before it is hardened; this can be detected when the article is in the fire, and at a low heat. This fracture is sometimes found in the steel as it comes from the manufacturer, but is

very often caused in the forging by excessive heating, and oftentimes the hardener gets blamed for faults which belong to other men. If there is a crack in the steel when it is just red, it can be detected, but hardening will not mend it. It may be useful to some to know that if a piece of binding wire be bound round any article, and a piece of loom wrapped round the wire, the wire merely to keep the loom from falling off, and the article, after drying the loom, may be put in the fire and heated all over, and when sufficiently hot may be put into the water, and the part that has the loom round it will remain soft, because the water cannot penetrate through the loom quick enough to harden the steel. If the loom be on the middle, the ends only will be hard; but if the loom be on the ends, the middle will be hard, and the ends soft, and the mechanic will find this plan very useful in many cases. The less frequently the water used for the purpose is changed, the better it is for the hardening of steel; therefore, as it wastes, fresh water should be added, and as it is necessary to clean the tank out occasionally, it would be well before using fresh water, to make it hot by putting a bar of ignited iron into it, and let it get cold again before using it; for when quite cold water is used, there is always a risk of the steel cracking.

As there is such a variety of different shaped

articles, to speak separately of every one would require a whole volume, therefore I think the necessity for a much further minuteness of detail will be removed by a little observation and experience. My mode of treatment of steel in some cases may be classed, perhaps, among those inventions which some are apt to wonder they never thought of, and, like many other things, very simple after they are made known, the simplicity of which raises their value; but simple as they may appear to some, they are facts of great importance in the management of steel. By applying aquafortis to the surface of steel previously brightened, it immediately produces a black spot; if applied to iron the metal remains clean, but looks a little dull where the acid touched it. By this test iron may be known from steel, as the smallest vein of either will be distinguished by its peculiar sign. There are many large things broken by taking them out of the water before they are thoroughly cold; and some people are of the opinion that it is the action of the air on the steel which causes it to break, but my opinion is, that the middle of the steel not being thoroughly cold, and the outside being quite cold, the instant the steel is lifted from the water the middle begins to expand, and the outside being quite hard the expansion is more than the outside can bear, so it causes it to break. But be this as it

may, it is a real fact that if a large body of steel be taken out of the water before it is thoroughly cold, in nine cases out of ten it is sure to break. If a large piece of iron is heated and put in the water, and kept under the water a considerable time, after the outside of the iron is black, and then drawn out of the water, the heat from the middle of the iron will in a few seconds turn the outside to a red heat again. Water acts on steel in a similar manner. When first the article is put into the water, the water begins to act on the outside of the steel, cooling it gradually towards the middle; and if taken from the water before it is quite cold, the heat from the middle begins to act on the outside of the steel in a contrary way to the water, by straining the outside of the steel more than it can bear; and in most instances I have noticed, when I have been trying experiments, that as soon as the water dries on the steel, it cracks, and the larger the steel the greater the risk, so it is important that it should be quite cold before it is taken out of the water, if the article be any way large.

It is not requisite that the article should lie in the water till the water is dead cold, for in some instances the article is wanted for use as soon as possibly it can be had; in such cases, if the article is not too large to go into a handbowl, put the bowl under the water in the tank, and place the article

in the bowl, lift the bowl and the article out together, with the water covering the article in the bowl, and then sink the bowl with the article still in it into another tank of dead cold water, or under a tap, with cold water running on it, and it will in a short time be ready to lift it out. But if the article is too large to go into a bowl, put it in a bucket and act as I have stated, and it will then come out safe without a crack, and not crack after it is out. Hundreds of things break, by lifting them out before they are cold. I have had very large things to harden that have taken weeks to make, and had I not taken these precautions, which some are apt to think too much trouble, I should have had many a waster; but trouble I never think about, success has always been my aim, and experience teaches me to give this little information to those that have not had the opportunity of gaining the experience I have had. There are many things cracked in hardening, by heating the article all over, and then dipping it in the water half-way. Such things as taps, drifts, and numerous other articles, should always be hardened all over, if they are heated all over, and then if one part is required softer than the other, it is best to soften it after, or otherwise not to heat it farther than where it is required hard; for if they are heated all over, and you in dipping them in the water stop at any par-

ticular part, and hold it still in that spot, if the water is quite cold in nine cases out of ten there will be a crack at the very spot which is level with the top of the water, and in some cases it will break clean asunder at that particular spot, as straight nearly as if it were sawn through with a saw. But these cracks may be prevented in a very great measure by simply putting the water in motion, or moving the article quickly about when it is in the water; as far as it is required hard; the water is then prevented from acting so evenly round it. Or if a few coils of binding-wire be bound round the part intended to be level with the top of the water, and a coat of potash put about the wire, there will be no crack there, as it prevents the water from acting so suddenly on it. But in many things where the heat that is on the article is wanted to temper the part that is dipped in the water, such as chisels, drills, and the like articles; these things, when they are dipped to the depth required to harden them, should always be moved quickly about in the water, and it will prevent many a drill screwing off in that particular spot, and prevent many a chisel breaking. I have no doubt that many readers of this little book have noticed when they have been chipping, that their chisels have broken clean off, about an inch from the edge, with a very light blow from the hammer, and the cause of that arises in a great number of instances, from the chisel having been

held still in the water when hardening it; for the water cooling it across in a straight line causes the hardened part to tear from the other, yet not sufficient to show till it is struck with the hammer, and then it drops off, and if the break be examined it can be seen that the water did it. But these kinds of articles having the skin on the steel when they are dipped in the water, it prevents the water from having just the same effect on them as it does on articles previously brightened. I recollect once having a quantity of small drifts to harden, and I was requested to keep the heads soft, so I put a certain number of them in a box, with charcoal dust to heat them, and when sufficiently hot, I shot them into the water with the intention of softening the heads after; but I found upon examining them that I had a number of them very crooked, owing to their being very slight, and going from the box so suddenly into the water; so I adopted another plan. I heated a certain number together, and taking them out separately, dipped them straight and gently into the water, which answered the purpose so far. But it took a little longer to dip them separately; so thinking to save this extra time, I thought I would only dip them in the water as far as I required them hard, and that would save me the trouble of softening the part that was not required hard. But not caring about going ahead with any

quantity of things till I make myself sure that all is going on well, after I had done about two dozen I examined them, and I did not find one of them but what was cracked at the part that was level with the top of the water, so I dipped the remainder all over, and not a crack appeared in one after. I then made some lead red hot and dipped the parts that were required soft into it, and accomplished them very nicely. So I think I have said sufficient to convince the reader that what I say is correct, and there are thousands of people that have an opportunity of testing it, and I will speak of nothing but what I have proved from experience to be correct. But to describe minutely the various kinds of articles that I have had to do with would be more likely to tire than to please the reader. I will, however, give sufficient information, if properly studied, to enable the mechanic to harden and temper anything that comes to hand. It may be useful to warn him that drilling too large a centre in articles intended to be hardened is a very great evil, such things as taps, fluted rimers, and such like; for when hardened, if the centre is too large, there is almost sure to be a fracture at the bottom of the centre, therefore it is best, after the article is finished, to file the centre out, if it is not required in; but in some articles the centres are required in them after hardening. But if the hardener should meet

with articles that he considers have too large a centre in them, and that there is a risk of having a crack in them, if he stop the centre up with a piece of loom to keep the water out of it, there is little or no danger of its cracking.

I was once working for an employer that had a large order for taps, and he said that he did not approve of cutting the steel down into lengths with a chisel, for he found that a number of his taps had a fracture in them from breaking the steel after it was nicked round with the chisel. This I will admit is often the case if a dull chisel is used to nick it round with, and it will not be visible till after it is hardened, and then it shows. But this was not the case in that instance; for when I examined the taps, I found that the centres were too large, and at the bottom of the centres there were the fractures. I would advise all those that cut their steel down with a chisel always to keep a good sharp edge on the chisel, for the steel will then break easier, and be less liable to splinter. In hardening a number of articles at one time, it is best to put them all into a box together with some charcoal dust, let them lie till they have acquired the low red heat called cherry-red, and then empty the contents of the box into the water; they will then be very clean, without scales, and beautifully hard. It is a very good plan for all small taps; and as it

is usual to temper these things to a colour after they are hardened, it is necessary to know that they are all hard before beginning to temper them, for it will sometimes happen that there will be some among them that are scarcely hard. If the box has been taken from the fire before it has been properly heated through, then the middle articles in the box will prove not hard enough; so, to make sure of good work, always try them with a smooth file to prove them, for in some instances one bad article would get all the lot condemned, even if all the others were right. But the use of the file can be dispensed with if they are brightened on a buff, or a stone, which are the proper things for the purpose; for the persons that brighten them will find, if they are properly hard, plenty of brisk lively sparks fly from them when they are held on the buff; and if they are not hard enough there will be very little fire in them; therefore, with a very little attention, those that are soft can be detected and put aside, and heated again with the next batch. Dies may be put in a box, and hardened after the same manner. I have found red-hot lead to be a convenient thing to heat many things in; but to be constantly employed at it, I believe to be very injurious to the health. I have been employed at it for weeks together, and have felt very bad effects from it, and I always avoid using it except in cases

of necessity. Still, there are many things that can be accomplished better by heating them in lead than in any other way; such things as long fluted rimers, and various other things that are a great length, for they will always keep straighter by heating them in lead to what they will if they are heated in a common furnace. If the article be very long, it must not be put into the lead too suddenly, or it will be sure to go crooked, for plunging a cold piece of steel too suddenly into red-hot lead causes it to go crooked, the same as if plunged too suddenly into cold water. These should be gradually put into the lead, and gradually into the water, with a little salt in the water to keep it from bubbling, for it is not everything that can be straightened after it is hard without damaging it, or softening it again. Care must always be taken never to have the lead too hot, or the articles will be spoiled, for they will be found to be full of little holes, if closely examined. Before putting the articles in the lead it is necessary to rub them over with a little soft soap, or mix a little black lead with water, and brush them over with it, or plumbers' size, and they will come out of the water clean, without the lead sticking to them. If the black lead is used, they must be dried before they are put in the lead, for the hot lead is likely to fly if they are put in damp. Soap does not require to be dried.

One advantage in heating large fluted rimers in lead is, if they go crooked in hardening they can be straightened when hard, for as soon as the cutting ribs of the rimer are hot, they must be taken out and put in the water. The middle of the steel will then be quite soft, because, being in the lead such a short time, the middle has not got heated through, consequently the middle cannot harden; and if it go crooked, then by laying the rimer on a block of hard wood, or a block of lead, and putting a piece of wire into the grove of the rimer, and striking the wire with the hammer, it can be straightened without breaking it, even when the cutting edges are dead hard. If they are tempered before they are straightened, they will straighten the easier. There is little or no danger of breaking them if they are not allowed to get heated all through; such things as these will always be hot on the cutting edges first, and these are the only parts required hard. But in respect to small rimers, they cannot be straightened the same way, for they get hot all through almost instantly they are put in the lead, but are not so likely to go crooked as if heated in the fire. Small rimers, when they have gone crooked, I have taken from the water before they have got quite cold, and placed them between two centres, and given them a blow on the full side with a small mallet, or if laid on a block of hard wood it will answer the same.

But there is a great risk of breaking them if they are too cold when they are struck with the mallet; therefore, if any prove too crooked to straighten this way, it is best to heat them again. In these kinds of small articles the hardener, if he has a large quantity to do, must always expect a little waste; of small ones I used to average about one in two hundred a waster, and in the large size not one in five hundred. Any quantity of articles, such as drills, bits, &c., may be expeditiously hardened by dipping their points in the lead, and cooling them in water; a pair of tongs with long jaws is very convenient for holding a quantity at one time; if the articles are of an unequal thickness, and one jaw of the tongs be made hollow and one flat, a piece of soft wood may be put in the hollow jaw; the tongs will then grip them all; any quantity may be hardened as expeditiously as a single article, if there be sufficient lead. Another thing to be observed is, that the surface of melted lead becomes quickly covered with a skin, which is the effect of the air on the surface, and it wastes the lead so fast that it becomes an object of importance to those who use much to check its formation, or to convert it when formed into the metallic state again. Charcoal converts the dross into metal again; but if a covering of charcoal or cinders be kept on the lead, the dross will not form, for, if it is allowed to form,

the lead is not only wasted, but it is a great obstruction in putting the articles in, likewise in taking them out; lead is an excellent thing in which to heat any long plate of steel that requires hardening only on one edge; for it need not be heated any farther than where it is wanted hard, and it will then keep straight in hardening. But if it is heated all over in a furnace and put in the water all over, it will be warped all shapes and cause a deal of trouble in setting straight, especially to those who are unacquainted with the setting of hardened steel. If it is heated all over, and one edge only dipped in the water, the edge that goes in the water will be rounding, and the edge that does not go in the water will be hollow; this is owing to the steel expanding in hardening, for the steel expanding in hardening causes the edge that goes into the water to get longer, and the other edge being kept out of the water, and still hot, the hardened edge expanding longer pushes the other part of the steel round, causing the edge that is out of the water to be hollow. But if it is heated in red-hot lead, and the edge only that is required hard put in the lead, the other part will be quite cold; and when it is put in the water all over, the hot part will not have sufficient strength in it to alter the cold part, consequently the cold part keeps the hardened part true. The colder the water the more effectually it hardens

the steel. Brinish liquids produce rather more hardness than common water, but in most cases common water answers the purpose. Water holding soap in solution prevents the steel from hardening; but as there are many things used in machinery that require to possess the greatest possible degree of hardness, it is necessary with such things to use a saline liquid. Gauges, burnishers, and certain kinds of dies, require to be very hard, also, a file requires a nice, hard tooth. When steel is required to be made extremely hard it may be quenched in mercury. But this can only be done on a small scale.

ON THE TEMPERING OF STEEL.

A rod of good steel, in its hardest state, is broken almost as easily as a rod of glass of the same size, and this brittleness can only be diminished by diminishing its hardness. In this management consists the art of tempering. The colours which appear on hardened steel, previously brightened, are, a light straw colour, a dark straw, gold colour, brown, purple, violet, and deep blue; these colours appear in succession as the hardness gets reduced. There are various ways of tempering steel, dependent upon the nature of the articles, likewise the quantity of them, for, in a number of instances, a

great many articles may be tempered as expeditiously as a single one. To temper any article to colour it must be brightened after it is hardened, and then laid on a plate of hot iron, or upon a surface of melted lead, or in hot sand, or burning charcoal, or held in the centre of an ignited iron ring, or in the mouth of a furnace, or on a gas stove made for the purpose. But in constructing a furnace for hardening with, it is a good plan to have the top of the furnace made with a good stout plate of cast-iron, so that the plate will always be hot, and ready to temper anything that can be done on a plate; and it will do to put the sand on, and for many other useful purposes, especially if the plate be moveable, and a small opening left in the front of the furnace from the top down to the mouth, just to admit the tongs. If at any time hot lead is required the plate can be removed, and the pot of lead placed in the furnace, the plate can then be put back into its place. The opening in the front will be very convenient for getting the articles into the lead, and when the opening is not required it may be stopped with a piece of sheet-iron. With a furnace of this description it is surprising the amount of hardening and tempering that can be accomplished; for large things take a considerable time in heating, and while the hardener is waiting for them getting hot he may be engaged tempering on the top of the

furnace, and still have his attention on the other articles. In the way of case hardening, a man's sole attention is not required on the articles all the time they are in the fire, as many things lie for hours before they are ready to put in the water, and he may then be engaged in tempering; but if this plate should prove too hot for small articles, another piece of plate may be laid on the top of it, and the articles laid on the top plate. It is not every one, however, that has large quantities to temper, so as to require a furnace or tempering stove; but merely a few articles occasionally, such as hobs, taps, dies, drifts, rimers, chasers, drills, &c., for the use of the shop, in such cases the uses of the furnace can be dispensed with; for a small quantity they may be heated in a common smith's fire, and hardened in the usual way: taps may then, after they are brightened, be held inside of an ignited iron ring till a dark straw colour appears on the surface, and then plunged into cold water; this is the best temper for general use, but if it is intended for any express purpose, for cutting things that are extra hard, in such cases a light straw colour or yellowish white will be required. Hobs require to be a yellowish white, for as they are always required for cutting steel, it is necessary they should be hard; fluted rimers may be held inside of an ignited ring, and tempered to a light straw

colour. Dies may be hardened in the usual way, and when brightened, placed on a cold plate of iron, and the plate and the dies put upon a large piece of ignited iron, and tempered to the same colour as a tap—a straw colour. Chasers may be hardened in the usual way, and placed upon an ignited bar, keeping the threads some distance off the bar, and tempering to a light straw, or yellowish white. Drills may be hardened in the usual way, and the cutting part of the drill tempered to a straw colour, while the rest is not higher than blue, so that its liability to break when in use is greatly diminished. Chisels may be hardened in the usual way, and tempered to a violet colour; but if intended for cutting stone, a purple is required. Drifts may be hardened in the usual way, and tempered to a brown colour. Milling cutters may be hardened in the usual way, and tempered to a yellowish white. Saws may be hardened in the usual way, in which state they will be brittle and warped: they may then be put into a proper vessel, with as much oil or tallow as will cover them, and placed over a fire and boiled to a spring temper, or they may be smeared with tallow, and heated, till thick vapours arise and burn off with a blaze; they must then be hammered flat, and afterwards blued. But if they are intended for cutting

hard substances, such as steel, or iron, they must be tempered to a straw colour.

A very convenient way of tempering when there is a large quantity of articles to do, is to place them in a vessel with as much tallow or oil as will cover them, and place them over a slow fire till a sufficient heat is given for the temper required. When the oil or tallow is first observed to smoke, it indicates the temper called straw colour, and when the smoke becomes more abundant, and of a darker colour, this indicates a temper equal to a brown; after which it will yield a black smoke, and still more abundant; this indicates a purple, after which it will take fire if a piece of lighted paper be presented to it, but not so hot as to burn when the light is withdrawn, and this is equal to a blue temper. The next degree of heat will be that which is mostly used for springs, when a white flame will be seen to burn on the articles if they are lifted out at this heat, after which the oil burns away. To add further oil is useless; any single article may be smeared with tallow, and held over a fire, or in a gas flame, and its temper known in a similar manner. For springs if they are very slight, oil is the best to harden them, as they are not so likely to draw out of the proper shape; but if they are stout springs, water is best, for in hardening a stout spring in oil, the hardness is confined to the sur-

face; for if the springs are properly hardened, and the steel good, and boiled in oil to the temper I have stated, there is no failing in them. Solid tallow is better than oil for hardening steel, which requires considerable hardness, but must not be made brittle. Tallow differs from oil in the absorption of heat for its fusion, for steel that is hardened in oil has always a covering of coal round it which greatly retards the transmission of heat. Water holding soap in solution produces a similar effect; any large piece of steel may be made sufficiently hard to wear well in machinery without making it brittle by hardening it in a body of solid tallow. A great many young mechanics are quite ignorant as to the nature of boiling oil, or tallow, and are anxious to try the experiment of tempering springs in boiling oil; to those I wish to say a few words. I was once asked by a young man the way to harden and temper springs, and I informed him to harden them first, and if he had a quantity to do, to temper them in boiling oil, never thinking that he would attempt to do them on the fire in the house, and the result was that he nearly set the house on fire. I have just mentioned this circumstance merely as a warning to the inconsiderate, that they may not fall into the same error. They must not attempt to boil oil unless they have a place suitable for it.

EXPANSION OF STEEL.

It is a well-known fact among those who are in the habit of hardening, that the hardening of steel increases its dimensions; still there may be some that have had very little to do with it, that may yet be ignorant of it, therefore it may be useful to acquaint those with it. The amount of this expansion cannot be exactly stated, for it varies in different kinds of steel, and even in the same steel operated upon at different heats. But this expansion can be prevented in a great measure, by annealing the steel about three times before the article is completely finished; for instance, when the first skin is taken from the steel it should be annealed again, and then another cut taken from it and annealed again, and so on for the third time. I have found that articles treated this way will always keep their size better in hardening, than if the steel were only annealed once. This may appear to some to be a deal of trouble, but they will find there is a saving in the end, for hardened steel is very difficult to work, and the working of hardened steel is unknown to a great number of people, and many that know how to work on it, have not things convenient for it, such as buffs, laps, or stones; therefore, to keep the article as near the proper size as possible is a matter of importance. I have had articles that have only

been annealed once, that have taken many hours to lap to the proper size after hardening, and I have had articles of the same kind, and from the same steel, and hardened at the same heat, that have been annealed three times, that have scarcely required to be touched after they have been hardened.

ANNEALING OF STEEL.

In the annealing of steel the same care is required in the heating of it as there is in heating it for hardening, for over-heating the steel is as injurious in one case as in the other. In the process of annealing artists differ very much, some approving of heating the steel and burying it in lime, some of heating it and burying it in cast-iron borings; while others approve of heating it and burying it in sawdust. A far better plan is to put the steel into a box, made for the purpose, and fill it with charcoal dust, and plug the ends up so that the air is kept from the steel, then to put the box and its contents into the fire, till it is heated thoroughly through, and the steel is at a low red heat; it must then be taken from the fire, and allowed to remain in the box, without opening the box till the steel is cold. Then when taken out the steel will be nice and clean and very soft, and without those bright spots

which some mechanics call pins, and which are no small impediments to the filing and working of steel, and if any difference, the steel is improved by the process. A piece of stout gas pipe, with a bottom welded in, and a plug made for the other end, makes a very good box for a small quantity of steel; but, for a large quantity, the box must be large in proportion. If the steel is very large it is as well to make a charcoal fire to heat it in, and then let the steel and the fire get cold together before it is taken out, and it will be equally soft. But it sometimes happens that a piece of steel is wanted in a hurry, and the steel, perhaps, is too hard to work on, and cannot wait for its being softened in a box; in such cases it may be heated in an open fire, and buried in charcoal dust till it is cold, or if it be heated to a red heat sufficient to be seen in a dark place, and then plunged into cold water, it will work more pleasantly; but not so soft as if it were heated in a box with charcoal. There are many that do not know the value of a good tool, because the steel they work on has never been properly annealed, and before the tool has half done its duty it is worn out, or wants repairing: whereas, if the steel had been properly annealed, the same tool might have lasted ten times as long without repairing.

CASE-HARDENING OF IRON.

Case-hardening is an operation much practised, and of considerable use, and in this art there are many different opinions. The prussiate of potash renders iron nearly as hard as steel, by simply heating the iron to a red heat, and putting the potash on it, and plunging it in cold water, but this hardness is confined to the surface. But the greatest effect may be produced by an air-tight box and animal carbon alone,—such as horns, hoofs, or leather, just sufficiently burnt to admit of being reduced to powder, in order that more may be got into the box with the articles. Bones reduced to dust will answer the same purpose. The articles intended to be case-hardened are put into the box with animal carbon, and the box made air-tight by luting it with clay; they are then placed in the fire, and kept at a light red heat for any length of time, according to the depth required; in half-an-hour after the box and its contents are thoroughly heated through it will scarcely be the thickness of a sixpence; in an hour, double, and so forth, till the desired depth is acquired. The box is then taken from the fire, and the contents emptied into pure cold water; they can then be taken out of the water and dried to keep them from rusting, by riddling them in a sieve with some dry saw-dust, and they are then ready

for polishing. Case-hardening is a superficial conversion of iron to steel; but it is not always merely for economy that iron is case-hardened, but for a multitude of things it is preferable to steel, and answers the purpose better. Delicate articles, to keep them from blistering while heating, may be dipped in a solution of salt, and while wet also dipped into a powder of burnt leather, or bones, or other coaly animal matter.

SHRINKING OF STEEL.

As a slight mistake at times is the common lot of all, a few words will not be out of place upon the shrinking of such pieces of work as the mechanic may have had the misfortune of boring too large, and which would be useless but for the process of shrinking it smaller. Shrinking is simply heating the steel and plunging it in cold water, but should it not prove small enough the first time, the operation must be repeated, and if insufficient the second time, it must be operated upon the third time, which generally effects the purpose. After the third time, I have generally found the hole to cast either oval or bell-mouthed, but after shrinking it the third time, and the article still remaining a waster, there is another source open, which is simply

to heat it again, and dip it in the water half-way, leaving one-half of it above the water, and then to heat it again and dip in the reverse way, half-way in the water; this will often accomplish what other methods have failed to do. Small holes will shrink rather more if the hole be filled with loom; shrinking and expansion of steel vary so much, that I have, at a red heat, shrunk the hole in a steel ring considerably; and at a whitish heat on the same steel the hole has been considerably larger. Iron rings, or collars, may be shrunk after the same manner as steel, by simply heating and cooling in water.

Much might be said upon the various kinds of tools used in the turnery, but there is such a variety of them, differing in form and size according to the necessities, it would take a whole volume to do them justice; some turners are apt to think the tools of their invention best of any, and their attachment to them, not to say bigotry, is often accompanied with a silly attempt to conceal from their fellow-workmen the benefits of their amazing discoveries as to the best shape of a tool; but having had good experience in tools, and their different shapes, I give it as my opinion that the best shape of a tool is a tool that answers the purpose, does the work well, wherewith least steel is cut to waste in the dressing of it,

least time required in the grinding of it, and whose wear is longest without repairing.

CONCLUSION.

Before I close these details, I wish to offer a few sentiments to the consideration of the ~~young~~ artist interested in them, whether he is one who is anxious to excel in this particular branch of art, as affording the means of honourable livelihood, or claims merely the appellation of an amateur, who studies mechanical operations from the love of knowledge, the desire of amusement, or the hope of celebrity in making discoveries or improvements. Let him not be discouraged by the failure of first attempts; instead of losing his time in uselessly regretting his disappointment, let him examine into the cause of it, and promptly repeat his experiments with more precaution. It is a mistaken idea that success is absolutely dependent upon length of practice, uncommon are the cases in which it fails to be the early reward of those who persevere; the reward will always be in proportion to the amount of perseverance and ingenuity displayed; there are always difficulties to contend with for the young beginner. But in every branch of art, if one source of experiment fail, there is abundance of other

sources still open. Further practical directions might easily be multiplied, but the necessity for much further minuteness of detail will be removed by a little observation, experience, and perseverance. But those who postpone perseverance, by satisfying themselves with the hope that length of practice will perfect them, will in the end regret their delusion, and may ineffectually try to recover their loss, when habitual languor, and other injurious habits, have rendered the mind averse to observe, and the hand unable to perform.

THE END

☞ *Any of these Books sent by Mail, free of postage, on receipt of the price.*

SCIENTIFIC WORKS

PUBLISHED BY

D. APPLETON & CO., 443 & 445 Broadway.

ALLEN'S Philosophy of the Mechanics of Nature. Illustrated. 8vo, $4 00.

ANTISELL, on the Manufacture of Photogenic or Hydro-Carbon Oils. 8vo, cloth, $2 00.

APPLETONS' Cyclopædia of Drawing—a Text-Book for the Mechanic, Architect, Engineer, and Surveyor. 1 handsome vol. royal 8vo. Profusely illustrated. New and revised edition, with many additional illustrations. Cloth, $6 00. Half morocco, $7 50.

APPLETON. Dictionary of Mechanics, Machines, Engine Work, and Engineering, containing over 4000 illustrations, and nearly 2000 pages. An entirely new edition, revised and corrected. With additional steel plates. Complete in 2 vols. large 8vo. Strongly and neatly bound in half morocco, $12 00.

——— Mechanics' Magazine and Engineers' Journal. Vol. II., 1852. Cloth, $3 50.

BASSNETT'S Theory of Storms. 1 vol. 12mo, cloth, $1 25.

BOURNE, JOHN. A Catechism on the Steam Engine. New revised edition, with illustrations. 12mo, cloth, $2 00.

BREWER'S North American Oology. Part I. Colored plates. 4to, cloth, $5 00.

BUDGE'S Practical Miner's Guide. New and enlarged edition. 8vo, cloth, $2 00.

BURGESS'S Photograph Manual; A Practical Treatise, containing the Carte de Visite Process, and the Method of Taking Stereoscopic Pictures. 12mo, cloth, $1 25.

CAIRD'S Prairie Farming in America. With Notes by the way on Canada and the United States. 12mo, paper, 25 cents; cloth, 50 cents.

CARRIAGE BUILDER'S and Harness Maker's Art Journal. [Published Monthly.] 1 to 18, in large 4to, with fine colored engravings. Each 75 cents.

———— The Same. Vol. I. Half bound, $10 50.

CLEAVELAND & BACKUS on Cottage and Farm Architecture. One handsome volume, 8vo, with 100 fine engravings. Extra cloth, $2 50.

CLEVELAND'S Hints to Riflemen. 1 vol. Copiously Illustrated. 1 vol. 12mo, $1 50.

COMING'S Class-Book of Physiology. 12mo, $1 25.

———— Companion to ditto. 63 cents.

COULTAS'S What may be Learned from a Tree. 1 vol. 8vo, cloth, $1 25.

DOWNING, (A. J.) Architecture of Country Houses. Including Designs for Cottages, Farm Houses, and Villas; with remarks on Interiors, Furniture, and the best mode of Warming and Ventilating. With 320 Illustrations. 1 vol. 8vo, cloth, $5 00.

FEUCHTWANGER'S Popular Treatise on Gems, in reference to their Scientific Value. 1 thick volume, 12mo. Finely illustrated. Cloth, $3 50.

FIELD'S City Architecture. 1 vol. 8vo, with 20 engravings. Cloth, $2 25.

FRY'S Complete Treatise on Artificial Fish-Breeding. 12mo, cloth, $1 00.

GILLESPIE'S (PROF.) Practical Treatise on Surveying. 1 vol. 8vo. With many engravings. $3 00.

GREEN & CONGDON. Analytical Class-Book of Botany. Illustrated. 1 vol. 4to, $2 00.

———— Primary Class-Book of Botany. Illustrated. 4to, $1 25.

GREGORY'S Mathematics for Practical Men. New edition. (London.) Half calf, extra, $10 50.

GROVE'S Correlation of Physical Forces. From the fourth London edition, with important additions to the American edition. 1 vol. 12mo. (In Press.)

GUYOT'S Meteorological and Physical Tables. 1 vol. 8vo, paper, $2 00.

HALLECK'S Elements of Military Art and Science. New and revised edition. 12mo, cloth, $2 00.

HAUPT, H. Theory of Bridge Construction. With practical illustrations. 8vo, cloth, $3 50.

HENCK'S Field Book for Railroad Engineers. 1 vol. 12mo, tuck, $2 50.

——— The Same. 1 vol. Half bound, $2 00.

HOLLY'S Designs for Country Seats, Country Churches, City Buildings, Railway Stations, &c. 1 handsome vol. 8vo, cloth, $3 50.

HUXLEY'S Man's Place in Nature. 1 vol. 12mo, $1 25.

——— On the Origin of Species. 1 vol. 12mo, $1 00.

JEFFERS. Theory and Practice of Naval Gunnery. 8vo. Illustrated, $3 00.

JOHNSTON'S Chemistry of Common Life. 2 vols. 12mo, cloth, $2 50.

LAFEVER, (M.) Beauties of Modern Architectnre. 40 plates. 8vo, $4 50.

LIEBIG'S Natural Laws of Husbandry. 1 vol. 12mo, cloth, $1 50.

LYELL'S Manual of Elementary Geology. New edition, enlarged and revised. 1 large vol. 8vo, with 750 woodcuts. Cloth, $3 00.

——— Principles of Geology. New and revised edition. 1 large vol. 8vo, cloth, $3 00.

MARTIN'S Screw Cutting Tables, for the use of Mechanical Engineers. Oblong. Cloth, 50 cents.

MORIN'S Practical Treatise on Mechanics. Translated by Bennett. 1 vol. 8vo, cloth, $3 50.

NICHOLSON'S Guide to Railway Masonry, containing a Complete Treatise on the Oblique Arch. 8vo, cloth, $3 50.

OVERMAN, (F.) Metallurgy; embracing Elements of Mining Operations, Analyzation of Ores, &c. Illustrated. 8vo, cloth, $6 00.

QUACKENBOS'S Natural Philosophy; embracing the most recent Discoveries. 12mo, $1 25.

REYNOLDS, (L. E.) Treatise on Handrailing. 20 plates. 8vo, $2 50.

SMITHSONIAN Contributions to Knowledge. Vol. II. 4to, cloth, $6 00.

SYDNEY'S Designs of Cottage Architecture. 5 Nos. In 4to, each 50 cents.

TANQUEREL'S Treatise on Lead Diseases. With Observations on Lead Pipe and its Substitutes. 8vo, cloth, $2 00.

TEMPLETON, (W.) Mechanic's, Millwright's, and Engineer's Pocket Companion. With American additions. 16mo, half bound, $1 50; in tuck, $1 75.

TRURAN on the Manufacture of Iron. New edition. Thoroughly revised and greatly enlarged. 1 large vol. 8vo, $10.

TYNDALL'S Heat as a Mode of Motion. 1 vol. 12mo, $2.

URE, (Dr.) Dictionary of Arts, Manufactures, and Mines. New edition, greatly enlarged. 2 vols. 8vo, cloth, $7 00; sheep, $8 50; half morocco, $12 00.

——— The same, complete in 3 vols. Cloth, $13 00; sheep, $15 50; half morocco, $20 00.

——— The same, Vol. III., or Supplement. One large vol. 8vo, cloth, $6 00; sheep, $7 00; half morocco, $8 00.

WARD'S Manual of Naval Tactics. With an Appendix on Naval Warfare by Steam. 8vo, cloth, $3 00.

WILSON'S Mechanics' and Builders' Price-Book. 12mo, cloth, $1 25.

YEAR BOOK OF FACTS in Science and Art, for 1860. 12mo, cloth, $1 50.

YOUMANS, (E. L.) Class-Book of Chemistry. 12mo. New edition, $1 25.

——— Chart of Chemistry, on Roller, $6 00.

——— Atlas of Chemistry. 1 vol. 4to, cloth, $2 50.

——— Alcohol and the Constitution of Man. 12mo, cloth, 63 cents.

——— Handbook of Household Science. 12mo, cloth, $1 50.

TRURAN ON IRON.

THE IRON MANUFACTURE

OF GREAT BRITAIN

THEORETICALLY AND PRACTICALLY CONSIDERED:

Including Descriptive Details of the Ores, Fuels, and Fluxes employed; the Preliminary Operation of Calcination; the Blast, Refining, and Puddling Furnaces; Engines and Machinery; and the Various Processes in Union, &c., &c.

BY W. TRURAN, C. E.,

FORMERLY ENGINEER AT THE DOWLAIS IRON WORKS, UNDER THE LATE SIR JOHN GUEST, BART.

SECOND EDITION,

Revised from the Manuscripts of the late Mr. Truran,

BY

J. ARTHUR PHILLIPS,

Author of "A Manual of Metallurgy," "Records of Mining," &c.,

AND

WM. M. DORMAN.

One Vol., Imperial 8vo, containing 84 Plates. Price, $10.

D. APPLETON & CO., Publishers.

SCIENCE BROUGHT DOWN TO THE PRESENT TIME.

A Supplement to Ure's Dictionary of

ARTS, MANUFACTURES & MINES,

Containing a Clear Exposition of their Principles and Practice.

(FROM THE LAST EDITION.)

EDITED BY ROBERT HUNT, F.R.S., F.S.S.

Illustrated with 700 Engravings on Wood. 1 vol. 8vo. Cloth, $6.00; Sheep, $7.00.

The Complete Work in 3 *Vols., Cloth,* $13.00; *Sheep,* $15,00.

The following extract from the Preface will explain the plan of the Editor:

"The objects which have been steadily kept in view, are the following: To furnish a work of reference on all points connected with the subjects included in its design, which should be of the most reliable character. To give to the scientific student and the public the most exact details of those manufactures which involve the application of the discoveries of either physics or chemistry. To include so much of science as may render the philosophy of manufacture at once intelligible, and enable the technical man to appreciate the value of abstruse research. To include such commercial information as may guide the manufacturer, and fairly represent the history and the value of such Foreign and Colonial productions as are imported in the raw condition. To present to the public, without much elaboration, a sufficiently copious description of the Arts we cultivate, of the manufactures for which we are distinguished, and of those mining and metallurgical operations which are so pre-eminently of native growth, including at the same time a sufficiently detailed account of the industries of other States.

"I commenced the New Edition of Ure's Dictionary with an earnest determination to render the work as complete and as correct as it was possible for me to make it. I soon became conscious of my imperfect knowledge of many subjects embraced within the scheme,—and even after having labored to acquire that knowledge from books, I often found there was still a want. In my necessities I have asked the aid of the manufacturer, and the advice of the man of science,—and never having been refused the information solicited, I am led to hope that those who may possess these volumes will find in them more practical knowledge than exists in any work of a similar character. For this they are indebted to the liberal feeling which marks the great manufacturers of England and distinguishes her men of science.

D. APPLETON & CO., Publishers.

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

DUE DEC 31 '24

DUE DEC 13 '35

DUE FEB -5 '41

DUE SEP -1 '42

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

DUE DEC 31 '35

DUE DEC 13 '35

DUE FEB -5 '36

DUE SEP -3 '40

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

DUE DEC 31 '[illegible]

DUE DEC 13 '35

DUE FEB -5 '[illegible]

DUE SEP -3 '[illegible]

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

DUE DEC 31 '34

DUE DEC 13 '35

DUE FEB -5 '40

DUE SEP -1 '41

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

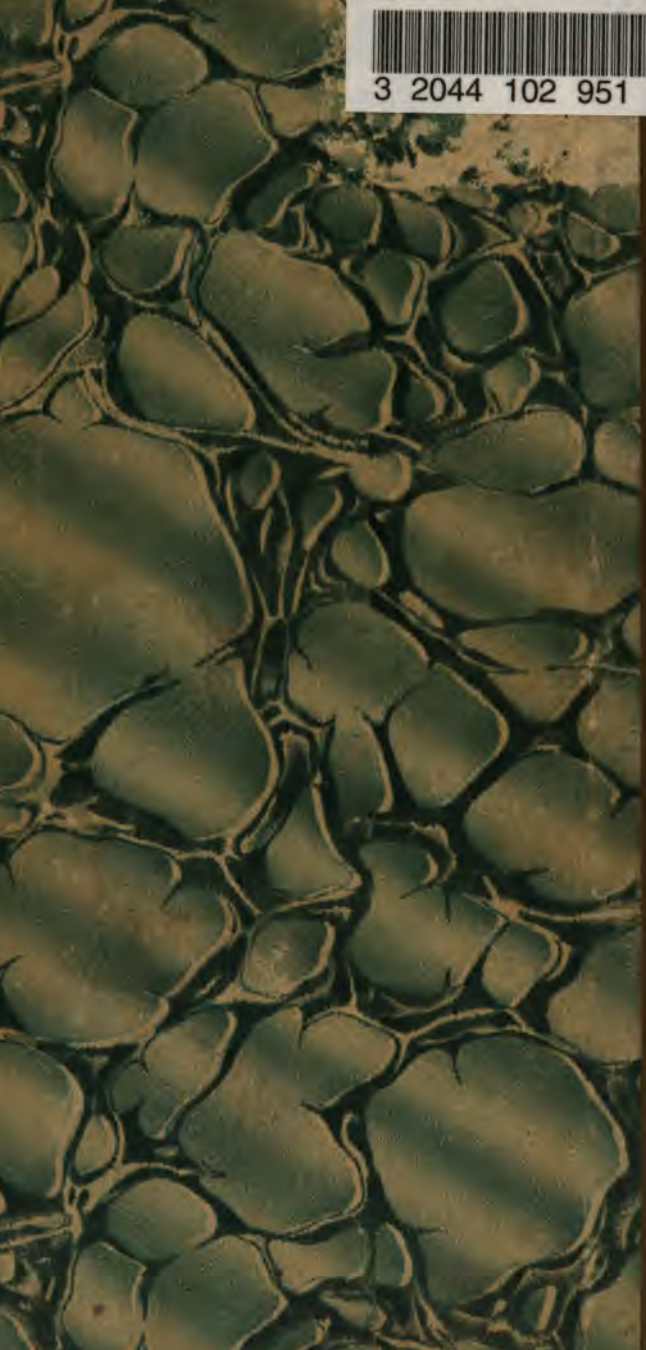
Please return promptly.

DUE DEC 31 '[illegible]

DUE DEC 13 '35

JUL FEB -5 '[illegible]

DUE SEP -1 '[illegible]


3 2044 102 951 472